Design of a Miniaturized Dual Wide Band Frequency Selective Structure

S. Singh, P.P. Sarkar, D. Sarkar, S. Bhunia, S. Biswas

Abstract- This paper deals with the frequency selective property of a structure comprising of a two dimensional array of patches. This frequency selective surface (FSS) acts like a dual band reject filter. The proposed design has been investigated theoretically using Ansoft Designer® software in which the reflection and transmission band have been predicted by the method known as Method of Moment which is most complicated but its accuracy is best. Efforts have been given to achieve dual high band reject filtering with high band ratio (approx 3.18).

Keywords- Bandwidth (BW), Band Ratio, Dual Band, Frequency Selective Surface (FSS), Resonating Frequency.

I. INTRODUCTION

In microwave engineering, Frequency selective surfaces or dichroics can be regarded as filters of electromagnetic waves [1-3]. An array of periodic metallic patches on a substrate, or a conducting sheet periodically perforated with apertures constitutes a frequency selective surface (FSS) [4-6]. Such structures have been well known in antenna theory for over half a century. They exhibit total reflection for patches and total transmission for apertures in the neighborhood of resonant frequency. The reflection and transmission band can be predicted theoretically by different methods viz. Finite Difference Time Domain method (FDTD), Finite Element Method (FEM) & Method of Moment (MOM) [7].

The frequency selective properties of FSS are exploited to make a more efficient use of reflector antennas in satellite communication systems which results weight reduction of the satellite and increases the working life of the satellite. The other application of FSS is to protect the Radar system using radome. FSS is also used in the domestic microwave oven screen window which blocks the microwave from coming out but passes the visible spectrum.

II. DESIGN

A. *First Design:*

In designing a patch type FSS The reference patch is a square copper patch of side 20 mm from which slits and slots have been etched out (as shown in Fig 1).

Manuscript received on January, 2013.
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A two dimensional array of this patch or unit cell has been designed with a periodicity of 24mm at both horizontal and vertical axes (as shown in Fig 2). All dimensions of the proposed design are shown in the fig1. The dielectric is Glass PTFE with permittivity of 2.4 & thickness of 1.6 mm is used.

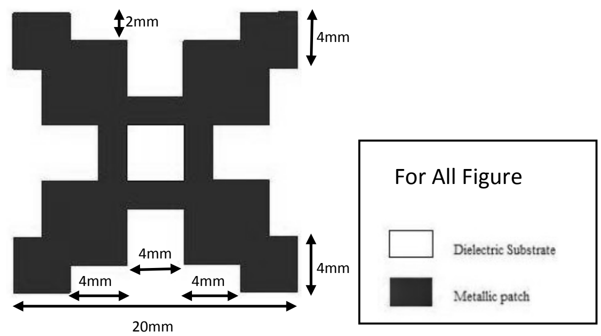

Fig.1: unit patch of FSS

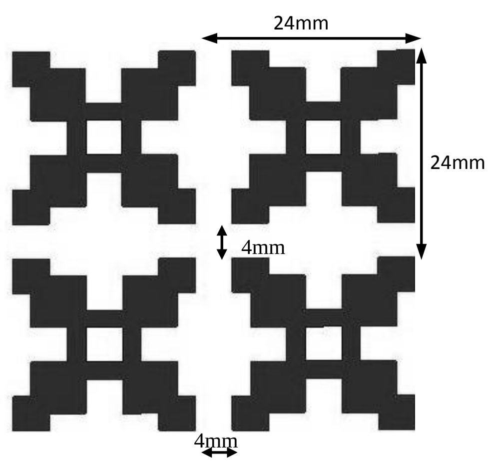

Fig2: FSS showing four unit cell and spacing between them.

B. *Modified Design I:*

In the further modification, small metallic square patches of side 4mm are added between the patches of the first design in the manner shown in Fig4. The unit patch formed out of this modified design is shown in Fig3. Hence, if we arrange the four units patch of Fig3 in the form of array with periodicity of 24mm both in horizontal and vertical axes, the modified FSS will be same as shown in fig 4.

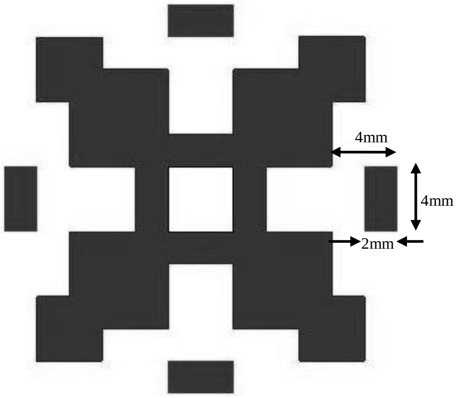

Fig.3: unit patch of FSS with modified design I

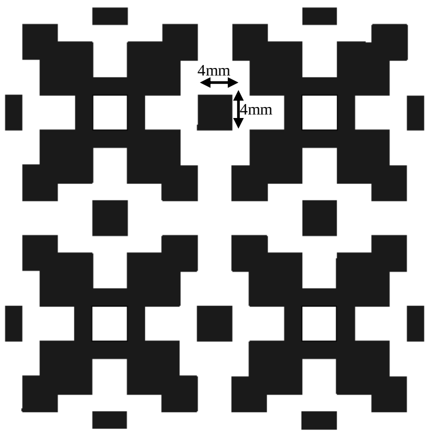

Fig4: FSS showing four unit cell with modified design.

C. Modified Design II:

In this design, rhombic slot and rhombic patch both of diagonal 6mm is introduced in the First design as shown in Fig 5 below. All other dimensions are same as shown in Fig 2.

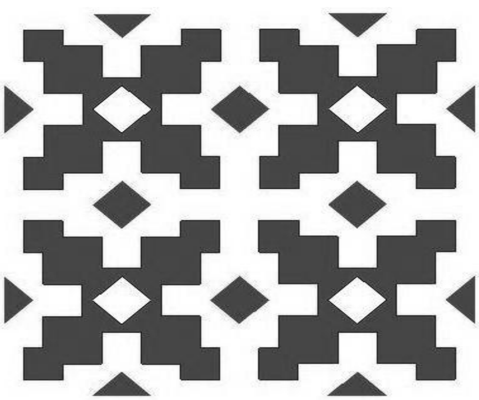

Fig5: FSS showing four unit cell with modified design II.

D. Modified Design III:

In this design, circular slot and circular patch both of radius 2mm is introduced in the First design as shown in Fig 6 below. All other dimensions are same as shown in Fig 2.

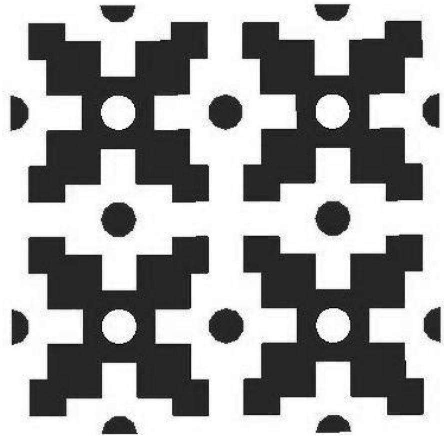

Fig6: FSS showing four unit cell with modified design III.

III. RESULTS

The first designed FSS resonates at three frequencies 5.54GHz, 11.41GHz and 17.24GHz. The -10dB reflection bandwidths recorded are 1.63GHz (wide BW), 0.1GHz (Narrow BW) and 1.43GHz (wide BW) respectively. Size reduction achieved in this structure is 75.75%. The corresponding transmission graph is shown in Fig 7

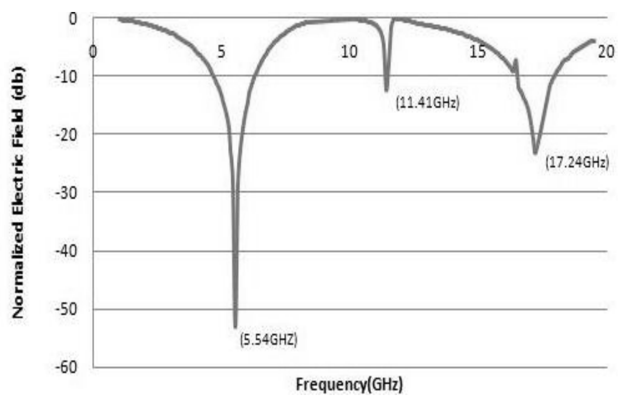

Fig 7: Normalized Transmitted Electric Field vs. Frequency for the First Design.

The modified designed FSSs resonate at two frequencies both being wide band.

Modified design I resonate at frequencies 5.36GHz and 17.07GHz and the -10dB reflection bandwidths recorded are 1.45GHz and 1.78 GHz respectively. Both are wide band. The corresponding transmission graph is shown in Fig 8.

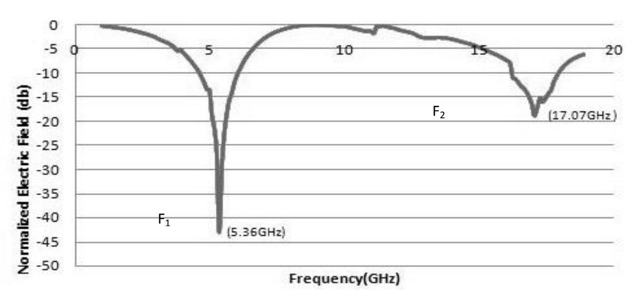

Fig 8: Normalized Transmitted Electric Field vs. Frequency for the modified Design.

Modified design II resonate at frequencies 5.45 GHz and 17.28 GHz and the -10dB reflection bandwidths recorded are 1.58 GHz and 1.43 GHz respectively.

Modified design III resonate at frequencies 5.59 GHz and 17.14 GHz and the -10dB reflection bandwidths recorded are 1.67 GHz and 1.65 GHz respectively.

The Analyzed numerical results of the above Four designs are summarized below in TABLE I.

TABLE I

FSS Design	Resonating Frequency (GHz)			Bandwidth (GHz), %Bandwidth		
First Design	5.54	11.41	17.24	1.63, 29.3%	0.1, 0.87%	1.43, 8.29%
Modified Design I	5.36	_	17.07	1.45, 27.05%	_	1.78, 10.47%
Modified Design II	5.45	_	17.28	1.58 28.99%	_	1.43 8.27%
Modified Design III	5.59	_	17.14	1.67 29.87%		1.65 9.62%

IV. CONCLUSION

From the observation of the theoretical results it can be concluded that the proposed FSS structure acts like a Band-Reject Filter. In the First design, the size reduction of 75.75% is achieved. From the simulated results and their corresponding graphs it can be inferred that here in the first design we are getting one vestige band at resonating frequency of 11.41 GHz along with two wide band. In all the modified designs this band is completely removed while all other features almost remain same. Hence finally we are getting a dual band stop filter with high bandwidths and high Band Ratio (f2/f1) which are 3.18, 3.17 and 3.06 for modified design I, II and II respectively. It totally reflects C band (4-6 GHz) and most of the frequency range of Ku band (12-18GHz). It can be used extensively in satellite communication.

V.ACKNOWLEDGEMENT

This research work was funded by DST PURSE PROJECT

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